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ABSTRACT

This presidential address before the Midwestern Education Research Association describes the chain of evidence that is required to link brain research to classroom practice; describes some of the proposed brain-based curricula and the kinds of evidence presented to support them; and suggests guidelines for evaluating proposals for implementing brain-based curricula in the schools. Three approaches to brain-based curricula are critically reviewed, including Hart's interpretation of MacLean's triune brain concept, Sample's discussion of left/right hemispheric processing, and the Epstein/Toepfer position on brain growth stages. In view of the deficiencies of these theories for educational practice, it is suggested that future research linking neurology to the classroom should test the links between neurological structures, neurological functions, psychological functions, and classroom learning. Educators considering implementing a brain-based curriculum should ascertain that the curriculum (1) is based on accurate interpretation and appropriate extrapolation of basic neurological research; (2) reflects the curriculum learning theory from which it originates; and (3) has been proven to cause the desired changes in learning. Concluding remarks assert that advances in knowledge about neurological processing within the next two decades will be applied in instructional technology and may require inquiry into the ethics of controlling learning. (Author/RH)

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Brain-based Curricula: Salvation or Snake Oil?

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Presidential address to the annual conference of the MidWestern Educational
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ABSTRACT

Brain-based Curricula: Salvation or Snake Oil?

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Examines (1) some of the claims made about the implications of current brain research for designing school curricula; (2) the chain of evidence that would be required to support such claims, and (3) several proposed brain-based curricula and the kinds of proof that are typically offered; and (4) suggests some guidelines for decision-makers who are considering investing in a brain-based curriculum.

Presidential address to the annual conference of the MidWestern Education Research Assn., Des Moines, Iowa, November 1981.

Brain-based Curricula: Salvation or Snake Oil?

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There have recently been strong claims that curricula based on neurological research will solve many school problems. Hart (1981a) says "If we use the knowledge of the brain now available, I believe we can make quantum jumps in achieved learning. Present failure can be virtually eliminated" (p. 445). He also promises that "The educator who sheds past confusions to see that the brain is the organ for learning enters an enchanting new world. Doors fly open on all sides; new pathways beckon, their potentials hardly explored" (1981b, p. 17).

Epstein claims that recent findings in brain research might "provide a basis for a theory of education for the first time in 3,000 years" (in Cramer, 1981b, p.17).

Toepfer (1979) asserts that the implications for education in Epstein's findings on brain growth "may be likened to that seen in the recent DNA findings in Biology. As the DNA findings have been designated as a 'New Central Dogma for Biology,' I feel that the brain growth periodization data base may well become a 'New Central Dogma for Education'" (p. 19). Sylwester (1981), also citing Epstein's work, states that "What we now know about the human brain and what we'll discover in the years ahead may well transform education" (p. 7).

While MacLean has usually limited his claims for the educational implications of "the triune brain", others have been less hesitant. Citing MacLean's work, Hart (1981c) states that "the 'whole brain' approach appears to open new doors and holds the promise of enabling schools to obtain enormously improved student learning" (p. 506).

Samples (1975) warns:

Science education can no longer afford being the resident of the left-cerebral hemisphere alone. Inventiveness and creativity are vital, and these qualities that . . . are genetically programmed into us are screaming across the barbed-wire

form to neurological function to psychological function to classroom learning (Figure 1A). The first step is to test the links between neurological form and neurological function. It is seldom safe to assume the nature of these links without testing. For example, while neurological structure may place some limits on

[Insert Figure 1 about here]

neurological function, we cannot assume from the absence of a given structure that certain neurological functions will not occur. There may be compensation or redundant storage of information or development of new pathways. There may be differences in function without apparent differences in structure, or differences in structure without apparent differences in function.

In assessing neurological form, neurological function, and their relationships, it is important to remember that evidence that is highly pertinent in one area may be less convincing in another--some questions, particularly some of those about neurological form, can be asked of dead brains, normal or damaged. Some questions about the relationship of form and function can be asked of a small reactive chain of cells. For the most minute elements of the process it is probably irrelevant whether those cells are squid or frog or human, but research that examines the larger organized programs of neurological processes may at some point need to test the accuracy of their findings for live humans.

The next step in the chain of evidence is to test the link between a given neurological process and a supposedly related psychological process. While some of the work relating neurological structure and processes to psychological processes can be done with the cooperation of our near or distant evolutionary cousins, such research must at least occasionally feature intact humans engaged in complex learning tasks. It is necessary for much of this work to use indirect and nonintrusive measures such as dichotic listening and conjugate lateral eye movements rather than scalpel and electrodes, but these indirect measures of neurological functions

must be well linked to relatively direct measures of neurological function, and their relationship to psychological functions and classroom learning should be examined rather than assumed. It is frequently the case that physiological or neurological processes have their own developmental course and are unrelated even to those psychological processes that are developing during the same period. (See, for example, Daly, 1981, or Daly & Hutson, 1981).

Similarly, while we may develop elegant models of the relationships that should exist between basic psychological processes and classroom learning, observed data from children, those notoriously uncooperative beasts, may undermine a lovely hypothetical network. If it is dangerous to infer links between identifiable psychological processes and the classroom learning behaviors that should be related to them, it is much more precarious to assume ties from observed neurological forms to unmeasured neurological functions to psychological functions to classroom learning, or to assume that through curricular changes we can modify basic neurological processes.

When basic research in any field is applied, new variables and interactions are introduced and there is a need for applied research. When principles derived from the chemical engineering lab, for example, are applied on the production line, it's necessary to test their effects in that multivariate setting. When principles derived from basic neurological research are operationalized as curricula, it is necessary to test their effects in school settings (see Figure 1B).

When brain-based curricula are instituted, they should be validated in terms of whether they (1) are based on accurate interpretation and appropriate extrapolation of basic neurological research; (2) reflect the curriculum/learning theory from which they flow; and (3) have been proven to cause the desired changes in learning. If changes in learning are observed, care must be taken to rule out possible causes extraneous to the curriculum (cf. Cook & Campbell, 1979).

Where neurological forms or processes are to be diagnosed in individual students, the diagnostic procedures must be validated both in terms of their correlations with other indices of neurological forms or processes and their correlations with measures of basic psychological processes or classroom learning. Where students, once diagnosed, are to be assigned to different instructional treatments, there must be evidence about whether their learning was greater than would otherwise have occurred and whether that change was caused by the treatment. It's not necessary that research proceed in the order described, or that any one study test all of these links, but in a serious research program all of these linkages should be established.

To recap: I have suggested a) that the evidentiary chain linking neurology to the classroom should test the links between neurological structures, neurological functions, psychological functions and classroom learning; b) that when brain-based curricula are instituted their effects should be assessed and the causes of change should be conservatively attributed; and c) that diagnostic instruments used should be well validated, and the effects of differentiated treatment should be assessed.

Major approaches to brain-based curricula

In this section I will discuss three widely reported approaches to brain-based curricula: 1) Hart's interpretation of MacLean's triune brain concept; (2) Samples' discussion of left/right hemispheric processing; and (3) the Epstein/Toepfer position on brain growth stages. Each of the three brain-based curricula is based on a different aspect of neuroscience and each will be examined briefly.

The triune brain. MacLean (1978) has described the "three brains" in man--the brain stem (reptilian brain or primal mind), limbic system (old mammalian brain or emotional mind), and cerebrum (new mammalian brain or rational mind), reflecting millions of years of evolution. MacLean (1976) has described his own work as "research relevant to the evolutionary and neural roots of imitation" (p. 188). He has studied

aggressive display by male green lizards and squirrel monkeys. Seeing another male, or in some cases, a mirror, "a male squirrel monkey will vocalize, spread one thigh, and direct the erect phallus towards the other animal" (p. 198). MacLean removed portion of the globus pallidus, (part of the "reptilian" brain) from the animal's brain and then studied the effects upon display behavior by the lizard or squirrel monkey.

Based upon this work plus his interpretation of evolution, MacLean has speculated on the effect of the older segments of the triune brain upon scientific creativity (1978), objectivity, personality, emotions, and intellectual territoriality (1977). (Many other scientists would hesitate to extrapolate so broadly from their research.) In the article most directly oriented toward education, MacLean (1978) speculated upon possible relationships between these older portions of our brain and human behaviors such as displacement of anxiety, deceptive behavior, fads and fashions, parenting, personality, right-handedness, and vocalization. Even here, though, he offered only a few comments on learning:

There is a significant gut component to learning (1978, p. 337). Punishment should be meted out immediately or not at all (p. 338). Once having mastered a verbal, musical or other exercise, we can later repeat it, so to speak, almost instinctively. (p. 339)

Most directly linking MacLean's experimental work with classroom implications is the statement that "Nature economically utilizes the R-complex for the reenactment of currently learned behaviors that have been emotionally conditioned through limbic functions or intellectually executed by the new mammalian brain " (MacLean, 1978, p. 339). While this statement is potentially applicable to understanding if not manipulating classroom learning, it appears to be a general observation rather than a summary of direct observation or a summary of experimental evidence related to classroom learning.

MacLean has made few suggestions for changing classroom learning, which may be just as well when we consider the experimental treatment upon which his work was based, unless classrooms are wild enough to require extremes in intervention. Hart (1981a), a lecturer on education, has been less reticent. Citing MacLean's work as support for his own "comprehensive, brain-based theory of human learning" (p. 443), Hart contended that

The brain is not designed for our schools. We have long demanded that students' brains conform to the school; we must now turn that around 180 degrees and see that schools...adapt to fit and not fight the brain. (Hart, 1978, p. 42)

He described children as "captive at a school desk, coerced to sit still and listen, to do only what they are told and even to start and stop that as 'ordered'." Under these "brain-antagonistic conditions", he contended, "school and brain are at loggerheads, and the consequences are the learning failures, discipline problems, confrontations, frustration, and boredom we see at every turn" (Hart, 1981a, p. 443). He also believes that "the conventional classroom is drenched with threat" (p. 445).

Hart claimed support from MacLean's research for his own curricular proposals (though the suggestions in the 1981 articles are similar to those in his 1978 article, in which he made no reference to the triune brain.) He proposed:

We can retain our political and financial school structures, our buildings and their staffs, as we set out to fundamentally change our instructional settings and methods. True, the willing and informed teacher can act immediately to reduce threat in his or her own room--but only to a modest degree, only by fighting the setting at every turn, and only within that one room. (Hart 1981c, p. 506)

Hart did not spell out remedies in that article, but in another article (Hart 1981a, p. 445) he stated that:

- "'Threat' must be minimal for complex learning"
- "Children must talk to learn"
- "Children must do to learn"

- "The raw material of learning from which patterns may be extracted...is needed in huge quantity and variety for learning"
- "Instruction that presents information logically, in an orderly way, in small increments, clearly and simply, is likely to prove ineffective--all the more so if it is heavily oral. What we have considered to be 'good teaching' simply does not fit the brain.... What is well intended and logical may actually have a negative effect."

The first of these statements is consistent with MacLean's positions (though MacLean had made no observations of complex learning in animals or humans). The next three are uncontroversial. While many of Hart's suggestions make a lot of sense, few of them seem related to the chapter by MacLean he cited or to the experimental evidence from which MacLean himself extrapolated. Only the last suggestion is controversial.

Hardyck (1981), a researcher in the area of brain functions, disputed Hart's interpretation of MacLean's work. He pointed out contradictions within Hart's (1981b) article and questioned the applicability of the triune brain concept to education. He concluded: "I do not agree with Hart's conceptions of brain function. I do agree with his concerns about education" (Hardyck, 1981, p. 507).

Whether or not one agrees with Hardyck in rejecting Hart's theories about the relationship between the brain and the classroom, it is important to remember that the principal source of empirical support for this approach is the display behavior of monkeys and lizards after parts of their brains have been removed. The most puzzling thing about this approach, as applied to humans, is how a school can, in a brief period, be expected to undo or improve upon what has taken nature millions of years to develop.

Hemispheric specialization. A second approach to brain-based curricula is justified in terms of a very different aspect of neurological research, hemispheric specialization, which has indicated that the left and right hemispheres of our brain have

somewhat different functions. Samples (1975), a teacher educator, interpreted the neuroscience literature in this way:

"There are two minds in our brain. One is rational-linear and logical in function, and the other is metaphorical-intuitive and analogic" (p. 21).

He further explained:

The right cerebral hemisphere is a metaphoric-intuitive hemisphere. It performs analogic functions and rambles through myriads of data simultaneously. The left cerebral hemisphere is far more constrained, and it sifts through inputs and reduces functions to logical-rational datum and acts more like a digital computer. (Samples, 1975, p. 21)

Samples was a curriculum writer for the Elementary Science Study and Man: A Course of Study. Watching children's reactions to these materials, he noted that "if trust were established, children preferred to start investigating with metaphoric-intuitive or right cerebral approaches" (p. 22). Based on these observations, he said, "We set about trying to create classroom environments in which the intuitive-metaphoric functions of the right cerebral hemisphere were as legitimate as the left-hemispheric function" (1975, p. 23).

Samples' rationale, following Bruner's (1965) metaphor of "left-brained" and "right-brained" processes, was that "intuitive right hemispheric functions have an intrinsic value of their own, and attempts to subject them to rational left hemispheric analysis--negative or positive--can be stifling" (Samples, 1976, p. 22).

By 1977, Samples was more expansive, mixing in a little archaeology, a little anthropology, a little developmental psychology, a little movement therapy, and a little neurophysiology, this time calling up not only the hemispheres but the corpus callosum (the primary communication conduit between the hemispheres) to support his notion that "we have essentially two 'minds' in our heads" and "they are located in different places" (p. 688).

Asking himself, "Where can we go?" Samples (1977) replied:

My answer is simple: across the corpus callosum. In work I have done for a decade and a half I have come to the conclusion that, though the rational mind has been favored, the metaphoric mind is well and waiting. In just the way that the idle left hemisphere waited until a period beginning nearly 10,000 years ago to make its presence known, our right hemisphere is ready to deal with the rational overload of contemporary times. (p. 689)

Samples faulted Piaget's theory of cognitive development as applicable only to rational, left hemisphere functions, and offered his own theory of four metaphoric modes: the symbolic metaphoric (the only mode rewarded in schools), the synergic comparative, the integrative metaphoric, and the inventive metaphoric modes (described in Samples 1977).

He reported that his curriculum materials for metaphoric thinking led to higher self esteem, wider exploration of traditional content subjects and skills, and higher levels of cognitive invention. No data on these changes were presented, though they may be available in project reports. Samples explained: "Because we were not going into areas that were well known in the literature or in educational experience, we could not use evaluation strategies that were bound into the standard decimal-placed-mentality research models" (1977, p. 690).

Samples also discussed the relationship of these modes to Piagetian cognitive developmental stages. No data on these relationships were offered, though Samples stated that "students from age 4 and at any grade level have the capacity to perform effectively in each of these metaphoric modes." He also claimed that "through use of the metaphoric modes these students were also able to develop more comfort and ability in exploring concepts, ideas, and processes in rational ways" (1977, p. 691).

There are some problems with Samples' formulation. The first question that might be asked is "Does his formulation adequately reflect basic research on hemispheric functioning?" His description of the relative roles of the two hemispheres is grossly true, but the relationship is much more complex than he suggests. Geschwind points out that "the specialization of the isolated hemispheres should not be overstated" (1979, p. 115). The same task may activate the left hemisphere initially and the right a few seconds later (Kraft, 1976). A task may require coordination of both hemispheres, or a task normally activating one hemisphere may be processed in the other by means of redundant storage or alternate pathways. Age of the subject, cuing conditions (Cohen, 1975), individual strategies, and relative difficulty of a task for a given individual may also be factors, requiring a more complex formulation than a right/left hemisphere dichotomy. (See Daly, 1981.)

A second question is "Are the research findings accurately presented?" Samples has stated:

At about age 12, most children enter the apex of logical conformity, the formal operations stage.... He/she will have given up intuitive, analogic explanations for those that are factual and explicit. In other words, the student will have become left hemisphere dominant. (Samples, 1977, p. 689)

If this statement is interpreted literally, it is contradicted by studies such as those by Kinsbourne (1978) which show that most children and adults use left hemisphere processing for some tasks and right hemisphere processing for others. If the statement is interpreted more loosely to mean that the student becomes predominantly logical, a number of studies suggest that even among college students there are many who have not mastered formal operations. There is also controversy about which hemisphere is dominant among formal operational thinkers. Brooks (1978, p. 8) points out the contradictory findings on this point.

Another question that might be raised is "Is there any link between hemispheric specialization and classroom learning?" While Samples points to neurological function as a basis for the classroom tactics intended to stimulate certain psychological functions, almost no data are presented to confirm these links. In fact, a recent report (Daly & Hutson, 1981) indicated no significant correlations between degree of hemispheric specialization and measures of language development, logical development, and educational ability in children.

And yet, Samples' curriculum seems interesting and possibly useful, (though it's quite possible that his metaphoric tasks call out left hemispheric processing.) While little evidence on program effects has been presented, it may be that Samples or others will be able to test more systematically students' status and strategies before and after treatment.

Samples has avoided some of the excesses that have characterized some of the other writings on implications of hemispheric specialization (cf. Houston's comments in Williams, 1977, on systematic right-side brain damage.) In attempting to gain acceptance for their own pet panaceas, some writers have claimed that we are raising a nation of left-brained students and that we should therefore inject large doses of "right-brained" activities into the academic curriculum or that instruction must be aimed at the right hemisphere for some students and the left for others. Wittrock has commented:

It is unfortunate that the simplistic notion of teaching to one or the other hemispheric process has become widespread and popular. As Chall and Mirsky indicate, curricula designed to avoid the teaching of skills such as reading or writing to certain groups of children who learn better with other skills can lead to serious gaps in achievement in culturally important areas of learning. (Wittrock 1981, p.15)

If we can leave out any reference to brain hemispheres except as airy metaphors for linear abstraction versus diffuse, holistic impression-gathering, and can test the effects of his curriculum, though, I see no major objections to Samples' suggestions. After all, as one who is reckoned by some poets a fair researcher

and by some researchers a fair poet, how could I fault a man who writes:

Education and culture have been biased against the whole. They have nurtured a part. But in silence the metaphoric mind has preserved the forgotten parts. The ghost of the genius of all humans lies within each of us. (1977, p. 692)

Brain growth periodization. The third approach is one that has recently received considerable publicity in journals read by educational decision-makers, and thus deserves especially close attention. The proposals by Epstein, Toepfer and their adherents are based on Epstein's (1974a) review/synthesis of a number of studies of brain growth, based on different variables, different ages and different sample sizes. Epstein and Toepfer have stated that most children of average and above ability have 7 periods of brain growth spurts and plateaus, alternating every two years (Toepfer, 1980a, p.223), with spurts permitting and plateaus ruling out advances in learning. For example, they state that "in, perhaps, 85% of all youngsters between ages 12 and 14, the brain virtually ceases to grow" (Epstein & Toepfer, 1978, p. 656). For this reason it has been suggested that during the middle school years "emphasis on affective and psychomotor aspects of learning should receive primary emphasis" (Gatewood, 1981, p.10).

This work was predicated on the connection most difficult to make--the assertion of a link between neurological form and classroom learning. Toepfer has stated that there is "a strong correlation of thinking level change to the appearance of new complexity in the neural networks manifested during the brain growth stages" (1980b, p. 8), and that these changes are related to success in classroom learning (p. 4). This is in effect a claim that all four of the aspects illustrated in Figure 1A (neurological form, neurological function, psychological function, and classroom learning) are tightly linked.

The Epstein/Toepfer proposals, however, do not simply attempt to define the relationship between neurological form and classroom learning. They propose to improve classroom learning and speed students through growth stages by (a) diagnosing students to determine whether their brains are currently spurting or plateauing;

(b) designing curricula appropriate for spurters or plateauers; and (c) matching students to the appropriate curricula. This requires validation of the diagnostic instruments both in terms of their relationship to brain weight and their ability to predict classroom learning, and also testing whether matching students to curricula causes them to learn better than would otherwise have been expected (Fig.1B). I use the word cause advisedly, to indicate the need to rule out other explanations for any observed change, and to indicate that control over the phenomenon must be demonstrated. There are other approaches to causality, but those standards are a convention in educational/psychological research.)

The first question that needs to be asked is "Are there brain growth spurts at 2-year intervals?" Careful examination of the original studies (Epstein 1974a and 1974b) suggests that this pivotal point, upon which all of the rest of the statements depend, should not too quickly be accepted as proven until confirmed by an independent source (cf. Arnold, 1981). Some have raised questions about this study--Were the cadavers studied representative of normal populations? (Some causes of death, for example, would cause swelling of the brain.) Were appropriate methods used to make the data comparable across studies? Would others, looking at graphs reproduced from the original studies, see gradual increases in brain growth rather than the spurts that Epstein saw? Were the measurement techniques used dependable? Was there a shift from Epstein's own initial qualified interpretation of spurts, to later broader statements (based on the same data), to the recent description of the spurts-and-plateaus as a "scientific fact?" (Toepfer, 1980b, p. 11)?

I will not raise these issues and will for the moment accept the Epstein/Toepfer position that there are, for children of average ability and above, cycles of approximately two years, alternating between periods of rapid brain growth (spurts) and periods of almost no brain growth (plateaus), and that for a period of about six months during the spurt period each student has his/her

individual spurt. To introduce new concepts during plateau periods, they say, is pointless because no new concept learning can occur, and "overchallenge" (Toepfer, 1980b, p. 7) leads to frustration and unproductive behavior.

I'll go on to the next question, "Is there a relationship between brain growth and neurological processes?" This relationship was assumed rather than tested in the original study and no evidence directly testing this point was offered later, though Toepfer has stated, "The incidence of a growth spurt means that the organ is developing the capacity for higher level functioning and the initiation of higher level capacities during that growth spurt" (1980b, p. 2). He has further stated that during the plateaus "there is virtually no brain growth with also no significant increase in the number of synapses. Likewise the axons and dendrites stop their dramatic lengthening and branching of the growth spurt periods and experience no further growth" (1980a, p.224). No reference is given for this broad statement, though in some articles Huttenlocher's (1979) research on synaptic complexity in two year olds is mentioned. Huttenlocher's work could support a statement that brain structure increases in complexity at age two. It could not support statements that this happens during every brain weight spurt or that increases in neurological or psychological functions or classroom learning are correlated with increases in brain weight.

While it's widely accepted that the brain increases in organizational complexity, no evidence is presented that the complexity stops increasing for two year periods or that it is correlated with individuals' increases in brain weight. (In fact, Himwich (1970) raises serious questions about the significance of brain weight.)

The next question to be asked is, "Is there a relationship between brain growth and psychological functions?" It may be true, as Epstein (interviewed in Cramer,

1981b, p. 17) says, that "every brain growth stage makes possible a functional increase in the intelligence of children," but no direct evidence is presented that shows, in the same individuals, links between changes in neurological form (brain growth) and changes in psychological function. The neurological form data are based largely on autopsies, with the cadavers unavailable for testing of neurological or psychological functions, and without data on their pre-morbid psychological testing and classroom achievement.

Although some of the Epstein/Toepfer reports state that there is a correlation between brain growth and Piagetian cognitive development, the evidence is at best indirect. It is suggested that the ages when spurts occur coincide with the ages at which various Piagetian stages begin. There are various ways in which the Piagetian stages may be "sliced"; depending upon the slices, they may or may not match the spurts. Piagetian theory and research do not suggest that there are sudden transitions to new stages every four years, or that all students of a given age should be at the same point in cognitive development, as the earlier Epstein/Toepfer articles suggest, or that they should be exposed to new concepts for only a few months out of every four year period, as their more recent articles suggest. Although it might be possible to assess the correlation of cognitive development with an indirect but well validated index of brain growth, no such data seem to have been presented. Another possible strategy for testing this point, though indirectly, would be to examine whether large data sets of Piagetian testing, such as the studies by Laurendeau and Pinard (1962), show for overall cognitive development the two-year on/off pattern.

Another question is "Are brain growth spurts and plateaus correlated with receptivity to new classroom concepts?" There are strong statements to this effect, but though empirical evidence may be available, it is not easily accessible. Epstein, in the discussion of the review of human brain and skull development, said "This phrenoblysic age spectrum for humans might be

correlated with spurts in mental abilities. On the basis of anecdotal evidence obtained by talking with teachers, we have reason to believe that the periods are correlated with spurts in learning ability" (Epstein, 1974a, p. 214).

"Can individuals' spurts and plateaus be diagnosed?" Toepfer (1980a) stressed the need "to identify when youngsters both enter and leave periods of growth and plateau...in their brain development" (p. 22). This technology, however, is not readily available and the relevance of brain size for psychological functions or classroom learning is not well established. Sylwester states that "we don't yet know how to determine when a given child's brain growth is beginning and ending" (1981, p. 8). The diagnostic instruments used, though described as means of identifying individual brain growth spurts, have in fact been measures of cognitive development.

"Is the proposed curriculum consistent with the theory?" Initially the curricular suggestions offered seemed to stress using the same program for all students of a given age and avoiding introduction of new concepts during the plateau periods, the troughs between the ages 3, 7, 11, and 15 (Epstein, 1974b, p. 217). There was stress on the notion that because of the limitations placed by brain growth, even very bright students of a given age could not proceed to a higher cognitive level. Epstein, for example, suggested that since 13 year olds are capable of "little new thinking capacity..., it might be worth postponing many learning activities until age 15," at which time they could presumably acquire the same new input "in about one-fourth the time it would take them about age 13" (Epstein, 1974b, p. 223).

More recently, though, Toepfer (1979, p. 20) has suggested that students can be moved more quickly through phases. Epstein has also said that "You can radically improve the level of learning in a child during these brain growth stages" (interviewed in Cramer, 1981b, p. 18). There was no direct test of either the earlier or later statements. The earlier statements would seem more nearly consistent with the theory, though less salable.

Movement to higher levels of reasoning is to be accomplished through "intensive stimulation that matches the current reasoning ability of the child" (Cramer, 1981b, p. 18). Epstein also states that "During plateau periods, I think it's important that kids memorize lots of songs and poems and parts of great literature" (Cramer, 1981b, p. 19). More generally, Epstein suggests that "children should be given lots of work and kept busy with challenging intellectual tasks--but at the level that is appropriate to their cognitive development" (Cramer, 1981b, p. 19). He stresses that during their plateaus students should not be exposed to concepts they had not mastered during their previous spurt.

The treatment Epstein used for 18 junior high school students in the midst of a plateau period was to take them out of school on Tuesdays and Thursdays to put them to work in day care facilities and nursing homes. (If this treatment were extended to many students, the implications for average daily attendance are unclear). Although the money ran out before the process could be repeated or followed up, Epstein stated that "From what we could see, the effort was very successful, even fabulous" (Cramer 1981c, p. 19). No data were presented.

Recently there has been more emphasis on individual differences and the need to determine whether individual students are in plateau or spurt periods. Toepfer (interviewed in *Brain Growth and the Curriculum*. . . 1980, p. 27) also suggested that since girls' brains grow three times as quickly as boys' between ages eleven and twelve, there should be segregation by sex at certain ages. He even raises the possibility that girls' brain capacity may atrophy by age 14 (Toepfer, 1980b, p.10). Toepfer indicates, though, that this is still a working hypothesis. The source of this statement about differential brain growth for males and females is unclear. This pattern is certainly not apparent in the graph of Boyd's data presented in Epstein (1974a).

"Do the programs work?" Some of the curricular changes suggested in the name of the spurts-and-plateaus theory make sense, and some school districts, by choosing carefully which aspects of the curricular suggestions they apply, may be facilitating learning. For example, the Shoreham-Wading River school district has trained a good proportion of their teachers about cognitive development and involved them in analyzing and modifying the cognitive demands of classroom learning tasks (Brooks, Mechovic, Arden-Smith, Grennon, & Daugherty, 1981). Although Epstein's work may have served as a initial stimulant, any effects from the treatment will owe more to developmental psychology and a good tax base than to neuroscience.

At this point the only indications of effectiveness are in the form of testimonials (Cramer, 1981c). While research is mentioned, the data are elusive. It is quite likely that some aspects of the curricular proposals, such as the individualization of cognitive demands based on the work of Inhelder & Piaget (1958), Arlin (1977), and Shayer (1980), have beneficial effects, and we can only hope that school districts making such changes will examine current literature on Piagetian approaches and set up evaluation procedures adequate to test the question clearly. The total Epstein/Toepfer curricular proposals, though, include delaying for a few years introduction of any new concepts, segregation during certain years by sex, improving the learning of plateaus by taking them out of school a few days a week (or perhaps even a few years; cf. Cramer, 1981a), memorizing stories and poems, etc. Validating the whole package will take a very bold school administration which has considered some of the questions raised here and a thorough evaluation that can separate out factors such as the halo effect.

[Insert Table 2 about here]

The question might also be posed as "Can the programs work?" One point that may disturb educators is the amount of time available for presenting new concepts. Take a worst-case example of Jenny, a reasonably bright girl born in June. She was too young to enter school in the September when she was 5 1/2, so she entered first grade at 6 1/2. The spurts in brain/body ratio during school age are said to be the years between 6-8, 10-12, and 14-16. Recent statements (Sylwester, 1981, p. 7) have suggested that for each student there is a spurt of about 6 months of rapid brain growth during each of these periods, and that for girls the spurts tend to come earlier than for boys (Cramer, 1981b, p. 17).

Let's trace the course of this girl's schooling. She has a brain growth spurt from age 6 to 6 1/2. Unfortunately, she's not in school yet, but fortunately another spurt comes along from age 10 to 10 1/2. The last half of her spurt falls during summer vacation, but that still leaves 3 months in which to present new concepts. Realistically, though, it takes two weeks for the teacher to realize that Jenny is spurting (it's the first time she's ever been receptive to new concepts in school), and during the last two weeks of school very little new learning takes place, so the period of new learning is reduced to 2 months. There's no reason to despair, though, since she should have another brain growth period from age 14 to 14 1/2. Again with vacation and other distractions (pray she doesn't get flu), learning time is reduced to 2 months. Even worse, for females during the 14 - 16+ period, brain growth is reported to be only one third that of males (Sylwester, 1981; Brain Growth and the Curriculum, 1980). And this is the last spurt; brain maturation is said to occur at 17 or 18. In twelve years of schooling the school has a total of 4 to 5 months of prime time in which to reach this student. During the rest of the time, though, she can practice what she has already learned and can memorize poems or learn psychomotor skills.

In sum, the questions about the Epstein/Toepfer proposals for brain-based curricula range from "Are there brain growth spurts?" to "Is there any evidence that spurts are related to cognitive development or classroom learning?" to "Can the proposals work?" Their statements may be true, but they are largely untested. For suggested research targets and tactics, see Hutson (1982.)

Comparisons of the Three Approaches

There are some differences between these three types of brain-based curricula. The purpose of MacLean's work is to understand prosematic behavior, "any kind of non-verbal signal--vocal, bodily or chemical" (MacLean, 1976, p. 192) controlled by the R-complex. The purpose of the work by Sperry, Kinsbourne and others (the foundation for Samples' statements) is to examine the role played by each hemisphere in humans' processing of verbal vs. spatial or auditory vs. visual or analytic vs. holistic stimuli. The purpose of Epstein's study was to test "the hypothesis that human brains have periods of specially large increases in weight that are uncorrelated or only weakly correlated with periods of general body growth" (Epstein, 1974a, p. 207).

MacLean's work is based on surgical experimentation with green lizards and squirrel monkeys, the work of Sperry (1973) and others is based on human split brain studies and noninvasive analogues, Epstein's work was based on human cadavers. The MacLean/Hart position credits us with three brains and three minds; the Samples position credits us with two hemispheres and two minds; the Epstein/Toepfer position credits us with one mind (at least for learning new concepts) -- sometimes.

Hart proposes unrestricted, unordered input and in fact sees harm in too logical a presentation; Samples asks for a balanced input including metaphoric as well as linear thinking activities; Epstein and Toepfer propose restricted input, withholding exposure to new concepts for several years at a time and suggesting that during the plateaus students learn specific facts and practical applications of concepts they've already mastered, staying out of school several days a week.

The research base for MacLean's position seems creditable, though the implications he draws extend far beyond the data base, and Hart extends the implications still further. Yet the suggestions for change are hardly revolutionary. The research base claimed for Samples' statements is unassailable, though still attempting to define a complex phenomenon. The tie from that research to his curricular suggestions is not secure, but some of his ideas are interesting and could be integrated into existing educational structures. The research base for the Epstein/Toepfer position, I believe, is shaky, and the statements about learning and schooling, though expounded with an air of scientific authority, need careful examination. While some of the ideas borrowed from Piaget are likely to lead to positive learning outcomes, other aspects of Piagetian theory are distorted to support their position. Some of the curricular suggestions they offer would require massive reorganization of the patterns of schooling, including withholding exposure to new concepts for several 2-3 year periods. Wittrock has warned that there are not "any findings that indicate we should stop teaching culturally important skills or subject matters to any group of learners" (Wittrock, 1981, p. 15). [Note: I have not reviewed here Wittrock's own approach, because it has not received the popular attention of the other three approaches and I have not yet had opportunity to read much of his work. My initial impressions are, though, that the less ambitious and more carefully researched approach taken by Wittrock will provide useful information, especially for individual learning/instruction.]

It is likely that within the next two decades we will learn a good deal about neurological processing and will be able to apply this knowledge in the form of instructional technology, especially in individualized learning delivered via computer. These technologies may even become reliable and powerful enough to force us to consider the ethics of controlling learning. That point, however, does not

seem imminent, and we would do well to heed Jeanne Chall's admonition that we need to "exercise modesty in classifying instructional programs as neurologically based when there is little or no evidence to support this claim" (1981, p. 11).

Sizing up brain-based curricula

Where does that leave us now? With a closetful of sound principles of learning and development that are insufficiently exploited, a handful of "brain-based curricula" that are perhaps overtouted, and some glittering possibilities just beyond the horizon. A decision-maker considering whether to invest resources in any curriculum justified in terms of brain research (or any other body of prestigious research) should ask these questions:

- ° Is the basic research accurately cited and interpreted and are the extrapolations reasonable (and labeled as extrapolations)?
- ° Have the links between basic neuropsychological processes and classroom learning been established?
- ° Even where correlations are established, can the relationships be manipulated ? (can learning be caused by taking neuropsychological factors into account)?
- ° Is evidence presented that such learning can occur not only for narrow objectives in a controlled situation but for complex learning in classrooms?
- ° Does the proposed curriculum reflect accurately the theory and research upon which it is supposedly based?
- ° Are convincing proofs of program effectiveness offered?
- ° Do any proposed diagnostic instruments (a) reflect and correlate positively with other measures of the theoretical construct; and (b) accurately predict classroom performance?
- ° Where it is proposed that students receive differentiated treatment, is there any evidence that matching students to treatments leads to increased learning?

- ° Even if a curriculum is offered with none of these proofs of pedigree, is it intuitively appealing--would you buy it without the fancy label, requiring only the proofs of impact that you would require of any curriculum (and, please, not calling it a brain-based curriculum)?

In conclusion, I see no salvation in current proposals for brain-based curricula, but even snake oil may have its uses. While it is not the preferred treatment in malignant cases, a school administrator may find desirable results if the recipe accidentally includes some healthful ingredients, convinces a hysterical patient that his symptoms are being cured or soothes school critics. All I ask is that decision makers read the labels carefully and discount all claims that do not meet reasonable standards of evidence.

Whether or not these relatively mild nostrums have effect, expect that in the not so distant future, science will provide stronger medicines, strong enough to raise troublesome ethical questions. The present may best be described in the words of F.H.C. Crick (1979, p. 130), "In spite of the steady accumulation of detailed knowledge, how the brain works is still profoundly mysterious."

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Figure Captions

Figure 1. The chain of evidence required to link neuroscience to classroom learning.

Figure 2. The time available for learning new concepts during brain spurts.

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Figure 1

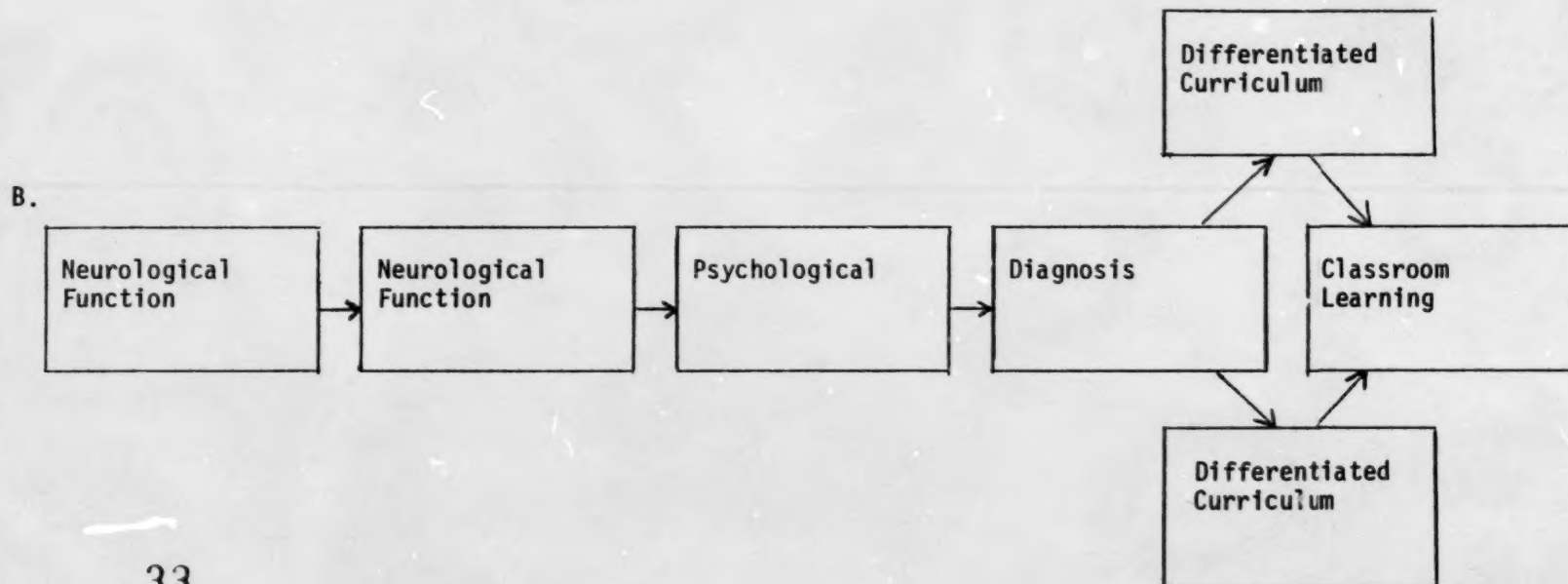
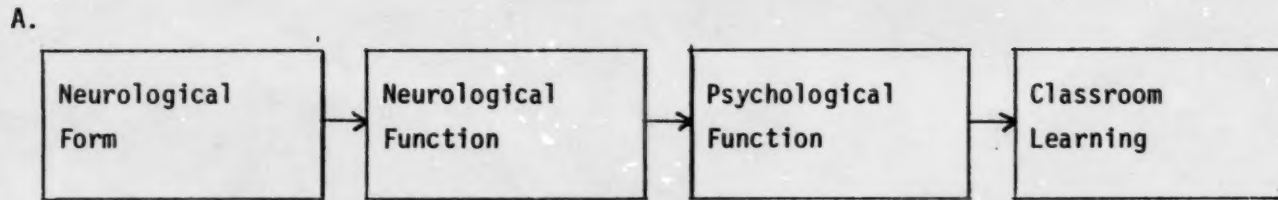


Figure 2

A.

Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	spurt	plateau	spurt	plateau	spurt	plateau	spurt	plateau	spurt	plateau	spurt	plateau	spurt	plateau	spurt	plateau	spurt

B.

Age	6	7	8	9	10	11	12	13	14	15	16	17	18
	○				⊕				⊕				
School Calendar		v		v		v		v		v		v	
Grade	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	

v = vacation

○ = spurt